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[54] **ELEVATED TEMPERATURE DEHYDRATION SECTION FOR PARTICLE DRYING PULSE JET COMBUSTION SYSTEMS**

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[52] **U.S. Cl.** **432/58**; 159/4.02; 159/4.03; 431/1; 432/25

[58] **Field of Search** 432/14, 25, 58; 431/1; 159/4.02, 4.06, 4.03

[56] **References Cited**

U.S. PATENT DOCUMENTS

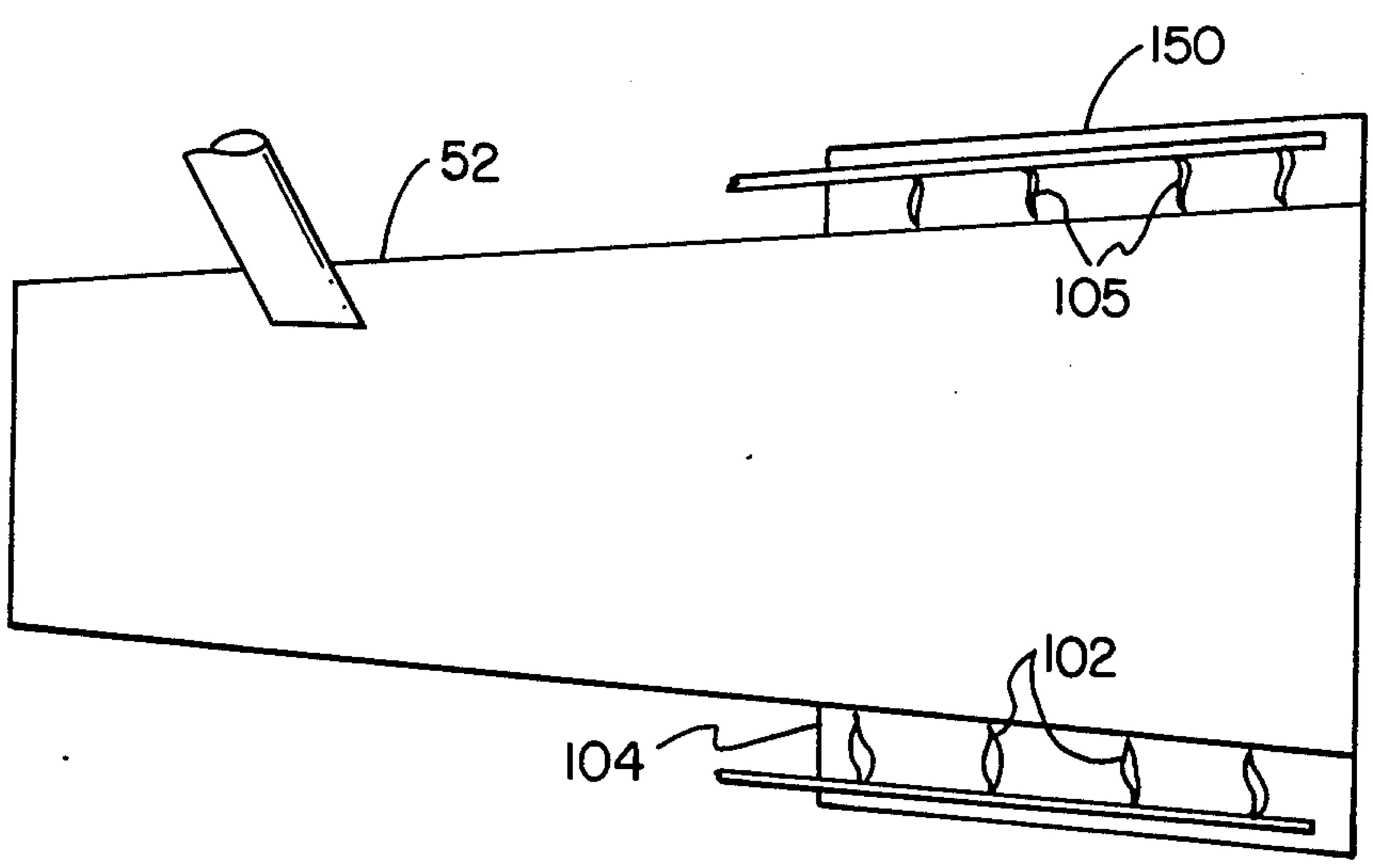
2,838,869	6/1958	Desbenoit et al.	239/587 X
3,133,805	5/1964	Robinson	432/58

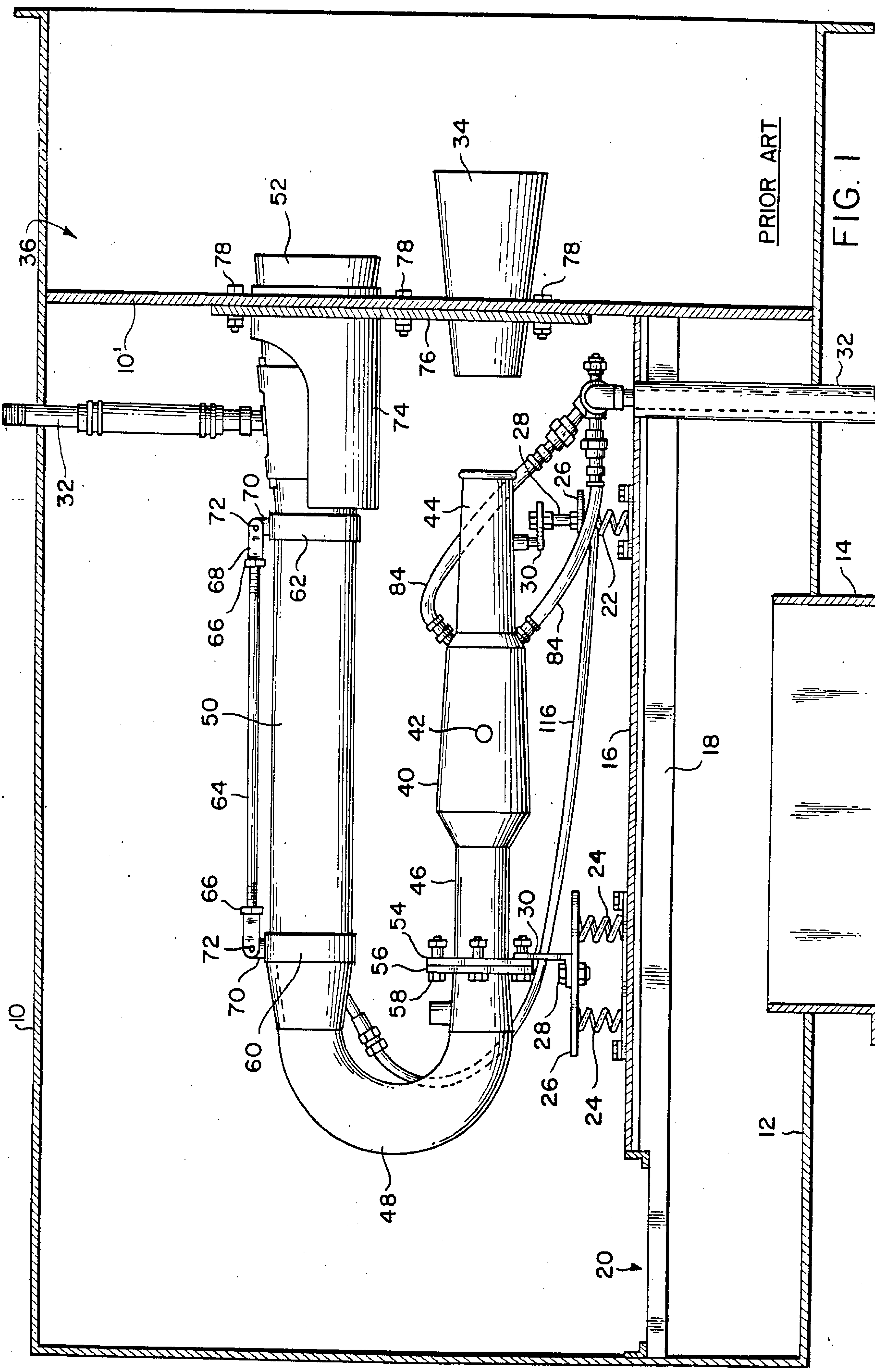
Primary Examiner—John J. Camby

[57] **ABSTRACT**

Improved construction for the dehydration sections of pulse jet combustors for the drying of particulate materials including provisions for maintaining the surface of the downstream end thereof at elevated temperatures.

4 Claims, 3 Drawing Figures





PRIOR ART

FIG. 1

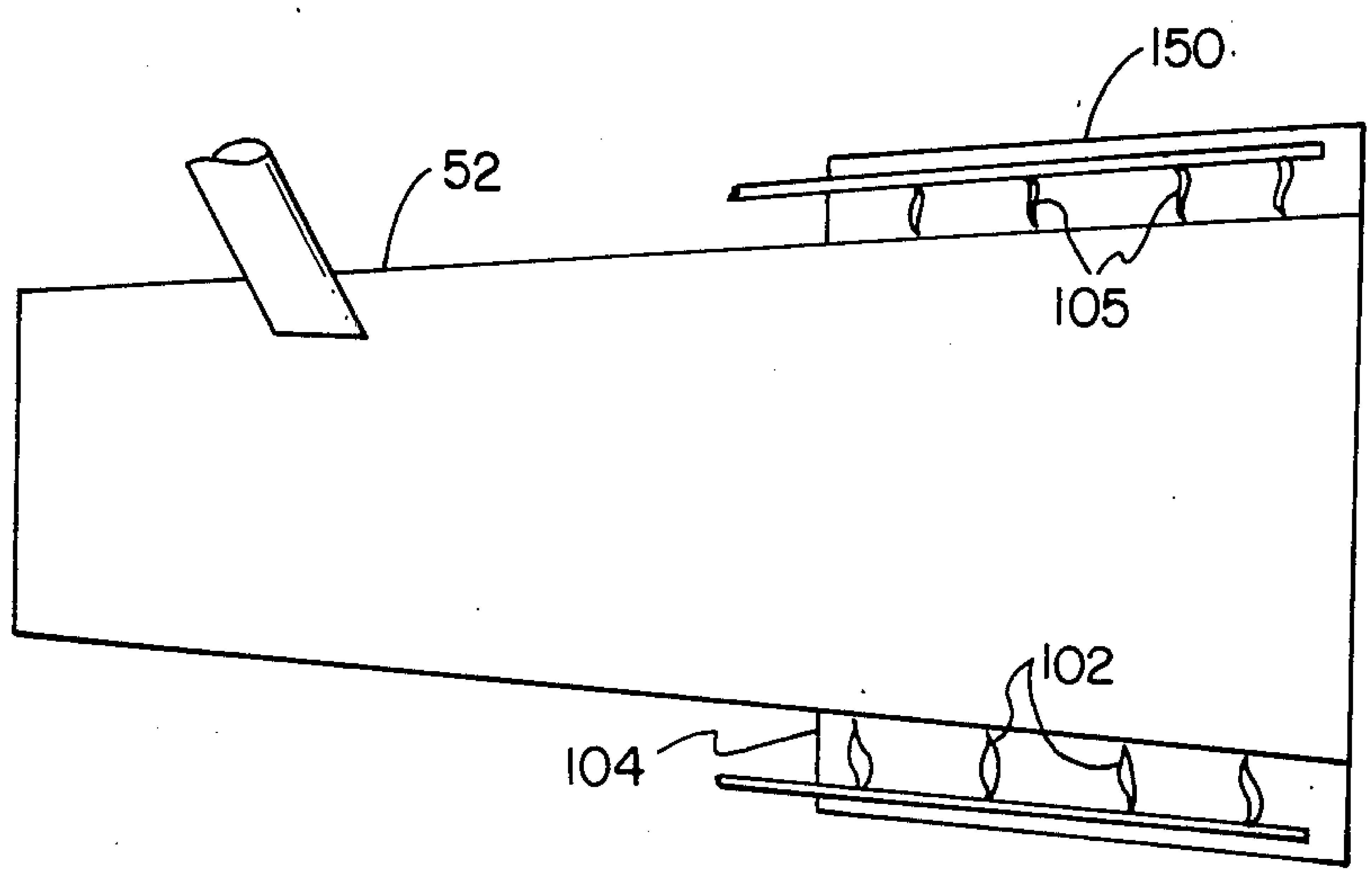


FIG. 2

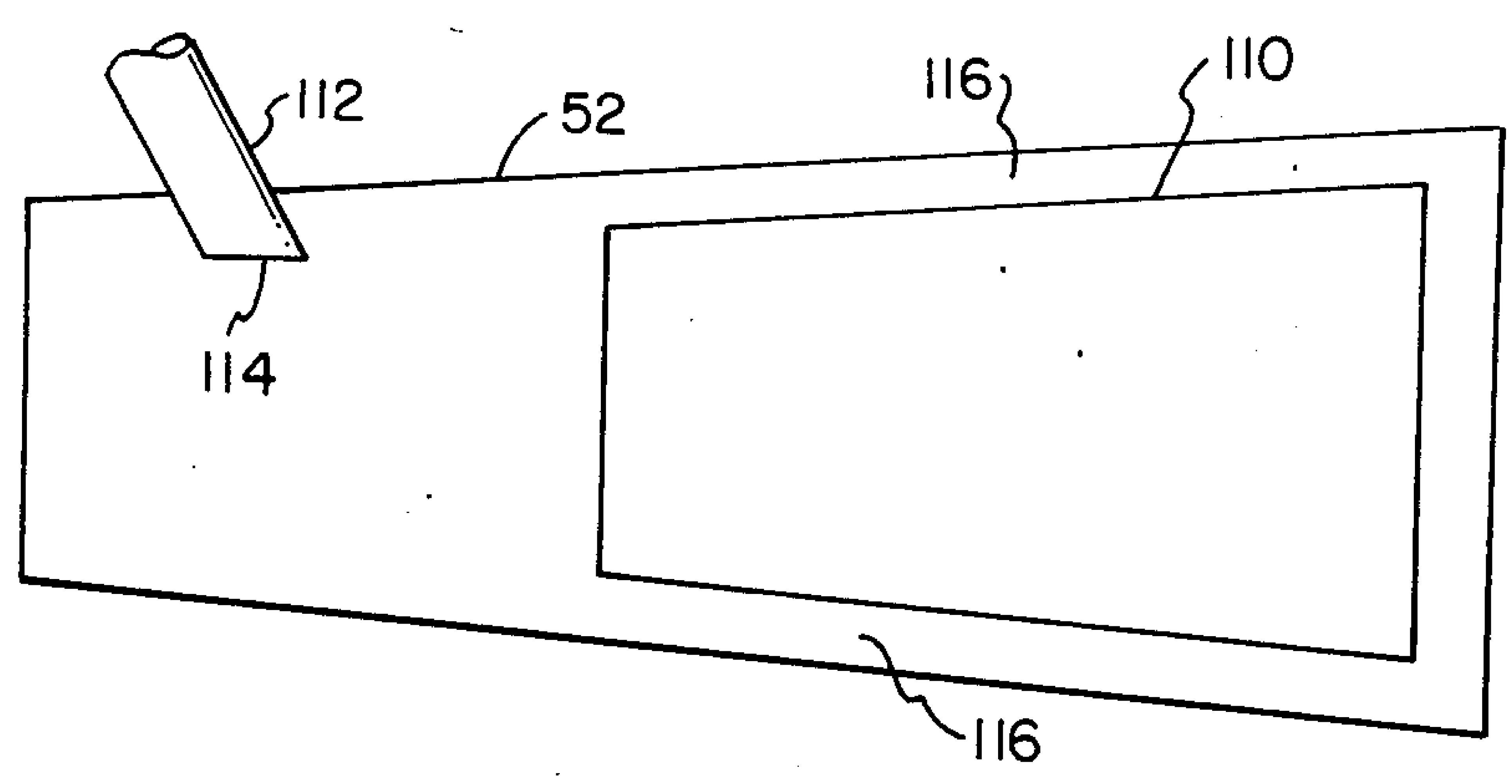


FIG. 3

ELEVATED TEMPERATURE DEHYDRATION SECTION FOR PARTICLE DRYING PULSE JET COMBUSTION SYSTEMS

This invention relates to the drying of particulate material and more particularly to improved methods and apparatus for the pulse combustion drying of particulate material.

BACKGROUND OF THE INVENTION

Pulse combustion drying, employing a pulse combustor essentially similar in nature to a pulse jet engine, is a relatively recent but recognized technique for effecting the drying of particulate materials. Illustrative of some earlier endeavors in pulse jet field for drying and other purposes are U.S. Pat. Nos. 3,618,655; 4,226,668; 4,226,670; 4,265,617 and 2,838,869. In the first of these patents a plurality of pulse jet engines are mounted at the base of a vertical chamber. A paste or slurry of the particulate material to be dried is introduced into the exhaust duct of such pulse jet engines which function to at least partially dry the particulate material and introduce it into the chamber where induced vortex gas flow causes circulation of the particulate material and consequent opportunity for further drying thereof. In the latter of these patents a linear pulse jet engine assembly for projecting various types of materials is disclosed.

A current state of the art pulse combustion dryer is made and sold by Sonodyne Industries of Portland, Oreg. The pulse combustor unit, which is the heart of the drying system, is a specially contoured and generally U-shaped hollow tube whose dimensions and materials of construction determine its operation. The pulse combustion process is initiated when air and fuel from a constant low pressure supply thereof are drawn into the combustion chamber portion of the combustor and ignited by a spark. Hot gases created by the resulting detonation move in both directions from the combustion chamber. In one direction, they pass through an air inlet conduit and adjacent air augmenter, and in the other direction, through a U-shaped exhaust section and past a raw material injection port at the downstream end thereof. Detonation in the combustion chamber causes the pressure therein to rise, momentarily shutting off the fuel supply. As the combustion chamber pressure falls following detonation, fuel is again admitted and mixed with air being drawn through the inlet conduit. Detonation occurs again, either because of contact between the explosive air-fuel mixture and the spark or by contact with the sufficiently hot wall of the chamber itself. Once the wall temperature reaches approximately 1800° F., the spark can be extinguished and the process becomes self-igniting.

The pressure fluctuation, which causes the pulsing behavior of the combustor, results in strong standing waves of sound energy which move in both directions from the chamber. Repeated detonations also create high speed displacement of hot gases with about 90% thereof exiting through the tailpipe and associated exhaust system components. Introduction of moisture laden particulate material into the downstream end of the exhaust sections subjects such material to the sound waves which, although not fully understood, are believed to break the bonds between the solid particulate matter and the liquid, most often water, and in an atomization of the water into fine droplets with a consequent increase in surface area for evaporation. The heat present in the exhaust gas interacts with the atomized cloud of introduced raw material allowing highly efficient evaporation to occur. During drying, the rapid evaporation of the water absorbs most of the heat and the solid particulates are maintained and exit in a relatively cool state. It should be noted that while operating temperatures in the pulse combustion exhaust system exceed 2500° F., the residence time of the raw product solids in contact with the exhaust gases is very short, being in the order of a few milliseconds. Because of such short residence time and the high heat consumption effected by evaporation, the temperature of the dried solid particulates rarely exceeds 100° to 150° F.

While pulse combustor drying apparatus of the type described immediately above has proved to be both efficient and economical in the drying of many diverse materials, certain problems have been encountered in the drying of particular materials. One such problem has been the undesired accumulation and build up of dried or partially dried particulates at the downstream end of the drying cone. Such accumulation, which appears sporadically but builds up rapidly when it occurs, mainly seems to occur with materials of high alkalinity such as drilling mud, brewers yeast and certain resins.

SUMMARY OF THE INVENTION

This invention may be briefly described as an improved construction for pulse combustion drying apparatus and which includes, in its broad aspects, method and apparatus for minimizing, if not avoiding, undesired sticking of particulate material at the downstream end of the drying cone by maintaining the inner surface thereof at elevated temperatures. In its narrower aspects the subject invention includes the maintaining of the inner surface of the downstream end of the drying cone at elevated temperatures through selective application of heat thereto, either through an external source of heat or by utilization of the elevated temperature of a portion of the combustor exhaust gas itself.

The object of this invention is the provision of methods and apparatus for minimizing, if not avoiding, undesired particulate accumulation of the downstream end portion of the drying cone for pulse combustor drying apparatus by maintaining the same of elevated temperatures.

Other objects and advantages of the subject invention will be apparent from the following portions of this specification and from the appended drawings which illustrate, in accord with the mandate of the patent statutes, a presently preferred construction for a pulse combustor drying apparatus incorporating the principles of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic side elevation of a pulse combustor drying system;

FIG. **2** is an enlarged vertical section of an improved construction of one embodiment of a dehydration cone construction incorporating the principles of this invention;

FIG. **3** is an enlarged vertical section of an alternative construction for a dehydration cone incorporating the principles of this invention.

Referring initially to FIG. **1**, a conventional type of combustor dryer system as there depicted broadly includes an isolating enclosure **10**, desirably of double walled sound-proof character, having an air inlet conduit **14** on the bottom wall **12** thereof. Disposed within the enclosure **10** is a platform **16** supported on beams **18** in uniform spaced relation to the enclosure bottom wall **12** and generally forming an inlet air plenum therebetween. The rearward end of the platform **16** terminates short of the rear wall of the enclosure **10** to provide a large opening **20** for the passage of air upwardly from the air inlet conduit **14**.

Also as illustrated, the pulse jet combustor is mounted in a resilient manner above the support platform **16** so as to cushion the platform and enclosure walls from vibrations incident to the operation of the combustor. Resilient mountings such as a front coil spring **22** and a rear pair of coil springs **24** extend upward from the platform **16**, and support mounting plates **26** at their upper ends. Bolts **28** secured removably to the plates **26** serve to secure thereto brackets **30** which connect to and serve to support the front and rear portions of the combustor.

The pulse jet combustor includes a combustion chamber **40** of enlarged diameter provided with a spark plug **42** or other ignition means for igniting a combustible fuel-air mixture. Connected to the combustion chamber **40** is an air inlet conduit **44** which receives atmospheric air from within the enclosure **10**, and a combustion gas outlet conduit generally shown at **46**.

The combustion gas outlet conduit **46** communicates through an arcuate and generally U-shaped coupling section **48** with a tailpipe **50** which, in turn, communicates at its downstream or exhaust outlet end with a material dehydration section **52**.

In the illustrated embodiment, the combustion gas outlet conduit **46** of the combustion chamber section **40** is provided at its downstream or outlet end with a peripheral flange **54** arranged for removable connection to a corresponding flange **56** at the adjacent upstream or inlet end of the U-shaped coupling or transition section **48**, as by means of a plurality of bolts **58**. The downstream end of the coupling section **48** is fitted with an outwardly and forwardly projecting annular collar **60** dimensioned to freely receive therein the adjacent upstream end of the tailpipe section **50**.

The downstream end of the tailpipe section **50** is, in similar manner, freely received within an enlarged collar **62** secured to and extending rearwardly of the upstream end of a dehydration section **52** in the form of a hollow truncated cone and generally called a "drying cone". To facilitate tailpipe replacement the collars **60** and **62** are interconnected by a turnbuckle assembly which includes an elongated threaded rod **64** received at its opposite ends in threaded nuts **66**. Each nut is secured to a pair of laterally spaced lugs **68** which receive between them an ear **70** extending upwardly from the associated collar. Registering openings in the lugs and ears receive a pivot pin **72** for joining them together.

The dehydration section **52**, which is of elongated frusto-conical shape and will be hereinafter referred to as a dehydration or drying cone, extends through a mounting plate **76**, removably secured to a wall of **10'** of the enclosure, as by bolts **78**. As is apparent, the dehydration cone **52** terminates within an adjacent large volume collector room **36** wherein the majority of the dried particulates settle out and are collected in any suitable manner. A dust collector or other conventional particulate collecting device is usually connected to the gas exhaust system for such collecting chamber or room **36** to effect recovery of substantially all of the dried particulates.

A wet product inlet conduit **32** is connected to the dehydration cone **52** for introduction of the wet product into the cone in a direction substantially perpendicular to the direction of movement of the high velocity gases of combustion passing through the tailpipe and exiting from the downstream end of the dehydration cone **52**.

Combustible fuel, such as oil, gas, etc. is delivered to the combustion chamber **40** by one or more fuel supply lines, such as the two lines **84** illustrated, connected to the fuel inlet conduit **32**.

The plate **76** supporting the dehydration cone saddle **74** also supports a so called "augmenter" in the form of a hollow truncated cone **34** disposed in spaced axial alignment with the air inlet portion **44** of the combustion chamber **40** and which also extends through the forward engine room wall **10'**. In the described system, the augmenter **34** functions to direct the high velocity combustion gases emitted as back flow from the combustion chamber **40** and air inlet conduit **44** into the adjacent collector room **36**.

In the operation of the above described pulse combustor system, the combustor is activated by delivery of combustible fuel and air to the combustion chamber **40** where it is ignited by a spark from the plug **42**. A wet product in the form of a slurry, paste or moist particulate is fed, generally under pressure, through the material inlet conduit **32** from whence it enters the dehydration cone **52** in a direction substantially perpendicular to the direction of flow of high velocity combustion gases through the dehydration cone **52**.

While, as noted earlier, operation of pulse combustor drying apparatus of the type described above has proved to be both efficient and economical in the drying of many diverse materials, a problem of partially dried material "sticking" to the drying cone surface and a concomitant rapid build up thereof and degradation of combustor operation has been encountered with certain materials. Such "sticking" and material build up always appears to occur in the "low velocity" area at the exit end of the dehydration cone **52**.

Referring now to FIG. **2**, there is shown, on an enlarged scale, a dehydration cone **52** of generally frusto-conical configuration and of a continually expanding diameter in the direction of exhaust gas flow. In pulse combustor dryers of the type herein of interest, the temperature of the exhaust gas stream at the entry side of the drying cone will normally be in the range of about 2000° to 3000° F. As previously pointed out, the highly efficient atomization of the introduced wet material and rapid evaporation of the water content thereof results in a drop in the exhaust gas stream temperature to about 200° to 300° F. at the exit end of the drying cone **52**. Commensurately therewith the temperature of the downstream end of the drying cone **52** itself approximates that of the exhaust gas i.e., about 200°–300° F. In order to elevate the temperature of the downstream end portion of a drying cone **52**, externally applied heat is provided as by a ring burner assembly **100** made up of a plurality of inwardly directed gas jets **102** mounted in a sleeve type housing **104**. Control of the fuel/air mixture supplying the gas jets **102** permits the temperature of the surfaces of the downstream end of the drying cone **52** to be both substantially raised and also controlled at any desired temperature level. Such localized heat application will not detrimentally affect the basic pulse jet drying phenomena but will function to reduce, if not avoid, detrimental product sticking at the downstream end of the drying cone **52**.

FIG. **3** illustrates an alternative approach for elevating the temperature of the downstream end of a drying cone **52** to reduce detrimental product sticking thereat. As shown in FIG. **3**, a second and smaller frusto-conical shell **110** is concentrically mounted within the cone **52** and is sized to extend over a substantial portion of the length thereof, downstream of the locus of raw material introduction **112** with its walls disposed substantially in parallel spaced relation with the walls of the cone **52**. In this embodiment, the wet particulate raw material is desirably introduced, as at **114**, closely adjacent to the center line of the drying cone **52**. Most of the wet raw material emanating therefrom is picked up by the exhaust gas stream and passes through the inner shell **110** where the drying action continues in the manner heretofore described with its attendant drop in exhaust gas temperature. The confinement of the drying operation within the inner shell **110** however permits the passage of a portion of the high temperature exhaust gases through the annulus **116**. Since minimal evaporation of the carrier liquid will take place within this portion of the exhaust gas stream, the temperature thereof will remain sufficiently high to maintain the walls of both the drying cone **52** and the inner shell **110** at an elevated temperature and will thus function to reduce detrimental product sticking at the downstream end of the drying cone **52** and shell **110**.

We claim:

1. In pulse jet combustor apparatus for the drying of particulate material of the type having

a combustion chamber,

an air inlet conduit connected to one end thereof

a primary exhaust gas outlet conduit connected to the other end thereof,

an elongated transition-tailpipe section connected to said primary exhaust conduit, and

a frusto-conically shaped drying section of increasing diameter connected to the downstream end of said transition-tailpipe section having means for introducing particulate material to be dried therein,

the improvement comprising

means for maintaining the surfaces of the downstream end of said frusto-conical drying section exposed to said particulate material at an elevated temperature through localized selective application of heat thereto to reduce particulate stickage on such surfaces.

2. The improved pulse jet combustor apparatus as set forth in claim **1** wherein

said last mentioned means comprises a plurality of gas jets mounted in surrounding relation to the downstream end portion of said drying cone.

3. The improved pulse jet combustor apparatus as set forth in claim **1** wherein

said last mentioned means includes a frusto-conically shaped shell disposed concentrically within the downstream end of said drying cone and in spaced relation thereto to define a peripheral annulus accommodating a flow of high temperature exhaust gas therepast.

4. In the operation of pulse jet combustor apparatus for the drying of particulate material through introduction of wet particulate material into a stream of temperature combustor exhaust gas in a conical conduit,

the step of reducing sticking of particulates to the inner walls of said conical conduit by maintaining the downstream end portions thereof at localized elevated temperatures.

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